ISP

Telecommunications Interfaces for the Mid-1980s

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TELECOMMUNICATIONS INTERFACES FOR THE MID-1980s

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CONTENTS

TELECOMMUNICATIONS INTERFACES
FOR THE MID-1980s

EXHIBITS

I INTRODUCTION

- This report is part of INPUT's Telecommunications Planning Program. Designed to help senior managers and corporate executives evaluate some of the influences on the telecommunications interfaces for the mid to late 1980s, the report assesses opportunities and problems associated with the technology relating to communications interfaces. This report further:

  - Indentifies technological interface requirements.

  - Defines and analyses current and projected communications interface innovations.

  - Analyses the effect of standards on interfaces and their associated protocols.

  - Identifies the thrust and direction of growth and development upon telecommunication interfaces.

A. PURPOSE AND SCOPE

- The functionality of a network is dependent, to a large extent, upon the interface topology and protocols that govern the network. This report assesses some of these factors, and documents the rationale for the role of

the local area network and the use of network standards, the Open System interconnection model, and the major protocol arrangements that have been developed by the major computer manufacturers.

- With this information, the busy executive or manager can develop insights regarding network planning and utilization that will allow a more effective exploitation of the capabilities and limitations of telecommunications systems.

B. REPORT ORGANIZATION

- This report is organized as follows:

  - Chapter I is an introduction.

  - Chapter II is an executive summary, formatted as a presentation for group discussions, and emphasizing the key points within the report.

  - Chapter III is a technology review and analysis of some of the local area network considerations affecting the system.

  - Chapter V defines the protocols and describes the techniques used to facilitate communications.

  - Chapter VI contains the conclusions and INPUT's recommendations for effective telecommunications planning.

  - The Appendix contains the survey form used to conduct the interviews.

C. METHODOLOGY

- The information contained in this report was derived from the following sources.

  - Interviews with senior telecommunications planning, vendors, and information systems managers and executives. The questionnaire is in the Appendix.

  - In-depth interviews with senior planning managers and executives. (The questionnaire is contained in the Appendix.)

  - INPUT's own studies on telecommunications.

  - Open literature surveys.

- INPUT has taken the best practices and proposals and subjected them to further analysis to serve as a basis for this report.

D. OTHER RELATED INPUT REPORTS

- Interested readers are referred to the following INPUT reports:

  - Telecommunications Planning Methodologies, November 1984.

    - Defines and describes telecommunications planning techniques and processes, using the case example approach, and further identifies critical telecommunications planning issues.

- Telecommunications Annual Planning Report, December 1984.

  - An in-depth survey and analysis of the current state of the telecommunications industry, with emphasis on an assessment of the technology.

- SNA: Challenges and Opportunities, December 1984.

  - An in-depth evaluation of Systems Network Architecture and its ancillary hierarchies, including reference models, access methods, and protocols.

- Annual Information Systems Planning Report, July 1984.

  - Evaluates information systems trends and graphically plots critical IS management issues.

- Impact of Communications Developments on Information Services Vendors, December 1981.

  - Analyzes changing communications technology and services as related to information services activities.

- Effective Corporate Planning in the Computer Services Industry, December 1980.

  - Examines the level and extent of corporate, market, industry, and product planning within the Computer Services Industry. Emphasis is on corporate planning efforts.

- User Communication Networks and Needs, November 1980.

    - Identifies and evaluates changes in user needs within the communications field; with particular emphasis on network problems and solutions.

II EXECUTIVE SUMMARY

- This executive summary is designed in a presentation format in order to:

  - Help the busy reader quickly review key research findings.

  - Provide an executive presentation and script that facilitates group communications.

- The key points of the entire report are summarized in Exhibit II-1 through II-4. On the left-hand page facing each exhibit is a script explaining the exhibit's contents.

A. COMPUTER NETWORKS: COMMUNICATIONS SYSTEMS OF THE FUTURE

- There is little doubt that computer networks will be the communication systems of the future. Every form of human communication (including speech, music, photographs, and graphics) can be stored and transmitted as computer data. The past few years have witnessed the growth of specialized network services like point-of-sale systems and automatic teller systems.

- These networks, in turn, are evolving into shop-at-home and electronic banking systems. In addition, information retrieval and self-paced instruction are currently being offered by some cable television networks, changing cable networks from one-way broadcasting systems into two-way communication systems.

- In the business world, local area networks have attracted a great deal of interest from potential users.

- At present, local networks tend to offer specialized services. The day is fast approaching, however, when an organization's local network will be its sole communication system, providing internal and external access to information.

EXHIBIT II-1

COMPUTER NETWORKS: COMMUNICATIONS SYSTEMS OF THE FUTURE

- **Human-Generated Information Can be Transmitted**

- **Communication Is Computer-Oriented Network Activity**

- **One-Way Communications Becoming Two-Way Interactive Systems**

- **Local Networks Will Provide Access to Both Internal and External Information**

B. INTERCONNECTION IS A MAJOR CONCERN

- The interconnection of networks will be of major concern to those organizations that plan to make extensive use of local area networks.

    - For example, a number of large computer systems at one site will be able to communicate with systems at other sites through their respective local networks.

    - Instead of connecting each host separately to one or more long-haul networks, users will be able to connect independent local area networks to each other.

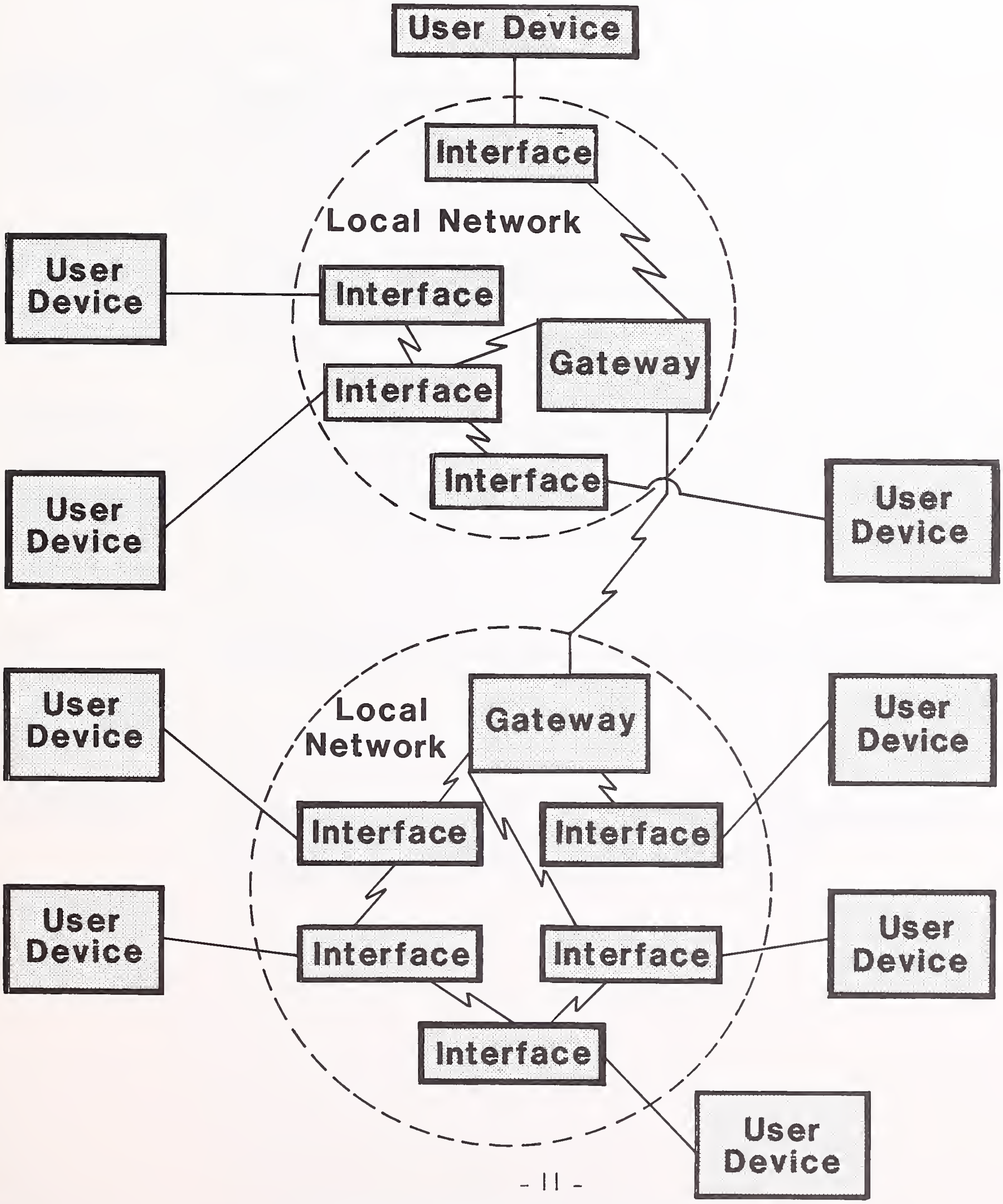
- The technology for interconnection networks is becoming available in the form of special internetwork devices called gateways. A gateway is a communication interface (usually a computer itself) connecting two or more networks.

    - Equipped with the proper interface devices and communication protocols, gateways serve as long-distance operators to establish connections between separate local networks through wide-area communication systems.

    - The exhibit shows a network configuration with gateways in place on both sides of the network. Note that the configuration can be made to work without the gateway, but that it would not be very efficient, since gateways typically provide protocal translation and message-buffering services.

EXHIBIT II-2

INTERCONNECTION IS A MAJOR CONCERN



C. STANDARDS ARE THE KEY TO COMMUNICATIONS

- For the foreseeable future, network vendors and communication companies will continue to go their own way. Ultimately, the marketplace will determine the networking approaches that will eventually become standards--resulting in different standards for different types of networks.

- The most important consideration in the design of gateways will be matching the protocols of the networks they join together. This raises the problem of standards. Although organizations such as the CCITT and EIA are attempting to develop standards for all communication networks, the day when every network operates according to the same protocols is not here yet.

- The selection of international standards will eventually allow vendors to mass-produce inexpensive interface devices capable of linking any user device to any network.

- Some of the committees involved in the establishment of standards are illustrated. Each of these represents a different approach to a certain set of needs, depending on the organization it represents.

EXHIBIT II-3

STANDARDS ARE THE KEY TO COMMUNICATIONS

ANSI	**American National Standards Institute**
ISO	**International Standards Organization**
CCITT	**International Telephone and Telegraph Consultative Committee**
EIA	**Electronic Industries Association**
CBEMA	**Computer and Business Equipment Manufacturers' Association**

D. PLANNING FOR GROWTH

- One factor that must be taken into consideration when local area networks are connected to long-haul systems is the matching of transmission speeds.

  - Since local area networks can transmit at much higher rates than their wide-area counterparts, outgoing data will arrive at a gateway faster than the wide-area network will be able to handle it.

  - A gateway serving such a system, therefore, will have to have adequate storage capacity.

- In the area of hardware, projections for future growth seem to be in the areas of transmission media and interface devices.

  - New techniques for improving the reliability and data rates for current media are already being introduced.

  - Fiber optics, an experimental medium a few years ago, is now being used in some specialized networks, and the use of this medium will continue to grow. Like the interchangeable modems used in today's data communication systems, such "off-the-shelf" components will contribute to the future reduction of networking costs.

- As costs decrease and the use of networks becomes commonplace, new applications will be developed. What these applications will be and how they will affect our lives remains to be seen.

- Network plans need to be structured with the future in mind.

EXHIBIT II-4

PLANNING FOR GROWTH

- **Match Transmission Speeds**
  - **Gateways Help**
- **Fiber Optics - A Good Alternative**
- **Reduce Costs**
  - **Off-Shelf Components**
- **Create New Developments**

III TECHNOLOGY REVIEW/ANALYSIS

A. THE ROLE OF THE LOCAL AREA NETWORK

- The movement toward extensive, integrated automated office systems will play an important role in the growth of intrafacility data communications systems and services--so called Local Area Networks (LANs)--during the 1980s.

  - Word processing is evolving to include a significant amount of electronic mail. Facsimile and copying systems will continue to be enhanced and integrated into the overall Office of the Future.

  - These applications, along with conventional data communications and message switching, will be prime candidates for integration via LANs.

  - Some common terminology associated with local networks includes:

    - Baseband--10 Mbps transmission rate, 2500 meter range, and using a form of coaxial cable.

    - Broadband--20 Mbps transmission rate, 50 mile-range, and using standard CATV coaxial cable.

. Collision Detection (CSMA/CD) or Token Passing (either ring-scheme or bus-scheme)--these are forms of polling employed to avoid transmission collisions.

- The local area network environment is currently extremely diverse and unsettled. The whole conception of the "Office of the Future" or, more appropriately, the "Automated Office" is very much unclear as regards the type of communications technology, switching, and data control to be employed.

  - At the present time, local networks typically operate in the 10-Mbps baseband frequency range. The trend will be toward broadband networks in the 25 to 40 MHz range, such as the local-network product currently expected from IBM.

  - By late 1985, local networks will begin to show substantially increased use of fiber-optic technology, especially above 20 MHz. This increase is due to fiber optics' low attentuation and high frequency response characteristics.

B. ETHERNET

- As more and more data within the office is stored and accessed electronically, a major new market for hardware, software, and distribution networks will be created.

  - Xerox has focused on the intraoffice distribution network requirements through the development of Ethernet.

  - Ethernet provides equal access to a variety of office workstations.

- As is the case in much of the telecommunications voice and data equipment marketplace (as well as in the data processing environment), standards are difficult to establish.

  - Xerox has submitted the Ethernet specifications to IEEE in hopes that IEEE will assign the Ethernet specifications as a standard for all LANs. IEEE, however, is developing its own standard based on more conventional data communications protocols such as HDLC.

- Teaming up with Xerox in the development of Ethernet has been Digital Equipment Corporation (DEC) and Intel Corporation. The affiliation of Xerox, DEC, and Intel represents a formidable alliance for developing a variety of Ethernet capabilities.

  - DEC has already released its first group of products, based on the Ethernet local area networking standard.

  - DEC believes that Ethernet will constitute one of the key elements in the data processing environment well into the late 1980s, comprising a major standard for equipment interconnection.

  - According to DEC, many existing DEC customers expect to install Ethernet systems in the near future, with thousands of systems expected during the 1980s.

- It is significant that DEC's initial Ethernet offerings will support DEC's network architecture only, permitting the higher level DECnet protocols to operate on the Ethernet baseband coaxial cable.

- DEC's Ethernet products will be based on board-level controllers. These new products will be sophisticated, intelligent devices providing more functionality than the DEC-compatible Ethernet controllers offered by Interlan Incorporated, a 3 Com Corporation.

C. OTHER SUPPLIERS/SYSTEMS

- In addition to Xerox, other companies have entered the local network area. There are several local area network suppliers at the present time.

  - The major manufacturers are:

    - Xerox (Ethernet).

    - IBM.

    - Zilog (Z-Net).

    - Ungermann-Bass (Net/One).

    - Datapoint (ARC).

    - Wang (Wangnet).

    - Racal-Milgo (Planet).

    - TRW-Sytek (LocalNet 20).

- Ungermann-Bass, for example, developed the Net/One local area network. This system is a single-channel baseband offering.

  - Eventually Net/One will also support broadband transmissions. The broadband products were announced in March 1982.

  - First deliveries of the broadband system products began during the summer of 1982.

- The Ungermann-Bass baseband and broadband systems are compatible so that they may be combined in designing intraoffice facilities.

  - It is possible to employ broadband systems where CATV cables are installed or where integration of broadband video systems are required.

  - A Net/One baseband system can operate at speeds up to 10 Mbps, whereas the broadband systems can operate at a maximum data rate of 5 Mbps on one of five standard 6-MHz channels.

- In the broadband configuration, the system functions with a single mid-split cable or with dual coaxial cables using vestigal side band (VSB) amplitude modulation similar to the modulation employed for normal television transmission. All operating frequencies are compatible with EIA broadband local area network standards.

- Net/One internetwork protocols permit easy communications between network nodes over several miles, including intercommunication between broadband and baseband systems.

- Ungermann-Bass offers identical protocol, device interfaces, and software for baseband and broadband systems. Because the two systems are virtually the same, costs are roughly comparable.

- In March 1982 Ungermann-Bass announced the addition of a broadband capability to its Net/One local area network.

  - Subsequently, the company said that it has signed an agreement with Fujitsu Ltd. to jointly develop and produce the first VLSI circuits for use in Ethernet and similar networks.

  - The two-chip set was designed by Ungermann-Bass but is produced by Fujitsu.

- The chip set is fully Ethernet compatible and is also compatible with the IEEE's standard for baseband Carrier Sense Multiple Access with Collision Detection (CSMA/CD).

- One of the VLSI circuits conforms to the Physical Layer (Level 1) of the International Standard Organization's OSI reference model and is used in baseband systems.

- The other VLSI circuit conforms to the Link Layer (Level 2) of the ISO reference model and can be used in both the baseband and broadband versions of Ungermann-Bass's Net/One.

• Another entry into the local area network arena is Racal-Milgo.

  - Developed in England by Racal-Milgo Ltd., the new system (called Planet) uses a token-passing access method to transmit over baseband coaxial cable in a 10 Mbps token-passing ring network.

  - Communications can be full or half-duplex. The network can accommodate a variety of protocols, assuming the end-user devices are in compatible communication.

• In 1982, 3 Com Corporation introduced the 3C400 Multibus Ethernet Controller, which connects Multibus computers to Ethernet.

  - The P.C. board version costs less than half as much as any previous controller.

  - The 3C400 is aimed at midrange Multibus Ethernet applications.

  - The device uses dual-ported memory. This enables one port to carry 10 Mbps packets to and from memory and the other to do concurrent

packet assembly and processing by protocol software located in the host computer. The Multibus controller includes hardware for CSMA/CD.

- TRW has recently purchased and installed LocalNet20, Sytek's broadband local area network.

  - The system links 192 ports in a terminal-to-host, host-to-peripheral network.

  - DEC VAX and CDC equipment can be used on the network. The network can also be expanded to cover a 50 kilometer radius.

- Within the last two years or so, Corvus Systems introduced the Corvus Concept, a personal computer designed to be a workstation on the Corvus Omninet local network.

  - The Concept features a Motorola 68000 processor, 256K of RAM (expandable to 512K), built-in Omninet interface (provides for computer interfaces to up to 4000 feet via twisted-wire pairs), EDWORD word processing software, Corvus LogiCalc electronic spreadsheet, and CPM emulator program.

  - The high-resolution, 8.5-by-11-inch display is bit-mapped and can be used vertically or horizontally. In full network configuration, the Concept costs roughly $5,000.

- Zilog Inc.'s Z-Net II provides a communications capability that supports a high-speed local area network link between multiple units of the company's System 8000, a 16-bit microcomputer family based on the UNIX operating system.

- The Z-Net II package includes a communications controller board, network transceiver, and an extended version of the U-Net software developed by 3Com Corp. The interface board is a communications processor based on the 16-bit Z8001 CPU.

- It includes 128K bytes of RAM and 32K of PROM.

- The Z-Net II package is available for a $7500 software license fee per site plus a $5000 purchase price per system.

D. NETWORK STANDARDS

- The local area network manufacturers above operate with no single network standard. The international data standards group is attempting at this time to develop an international standard that can be employed by various suppliers of local networks.

  - The IEEE is presently working on a local area network standard (802) that is expected to be completed shortly.

  - It may not be prudent to expect that a definitive standard for local area networks will be developed and generally employed in the near-term.

- The IEEE 802 Local Network Standards Committee has propossed two fundamental approaches for single-channel baseband local area networks.

  - The first is Carrier Sense Multiple Access with Collision Detection (CSMA/CD). The second is token-passing. Certain applications favor one method over the other.

- Unfortunately for Ethernet's supporters, the IEEE's proposed CSMA/CD standard is slightly different from Ethernet's CSMA/CD arrangement.

  - This difference opens up the marketplace for non-Xerox manufacturers of local area networks.

  - In addition, other vendors have developed a multichannel broadband local area network approach. Among these vendors are Wang (Wangnet) and Sytek Incorporated (Local-Net).

  - The broadband systems suppliers point to the advantage of carrying video and interactive voice in addition to data transmission capabilities; however, these suppliers point out that baseband local area networks are limited in scope and capabilities.

- As a result of the varying local area network product releases, the International Standards Organization (ISO) has developed a seven-layer reference model for network architecture, as shown in Exhibit III-1.

  - This model is referred to as Open Systems Interconnection (OSI) and has been accepted by most network designers as a basis for network development.

  - Local area networks such as Ethernet specify interfaces in protocol for only the lower two or three levels of the seven OSI layers.

  - This standardization provides for the connection of similar devices within the network; however, standard protocols at the higher levels are required for true interdevice operations.

- Information Systems managers will want to take these factors into account when planning their communications systems, particularly when developing their protocol compatibilities.

EXHIBIT III-1

THE OSI REFERENCE MODEL

LAYER	NAME	PURPOSE
7	Application	Selection of Appropriate Service for Application
6	Presentation	Code Conversion and Data Formatting
5	Session	Coodination of Interaction Between End-Application Processes
4	Transport	End-to-End Data Integrity and Quality of Service
3	Network	Switching and Routing of Information
2	Data Link	Transfer of Units of Information to the Other End of the Physical Link
1	Physical	Transmission of the Bit Stream to the Transmission Medium

- A review of protocol techniques will help visualize the importance of the standards as discussed thus far.

IV PROTOCOL TECHNIQUES

A. COMMON PROTOCOL TECHNIQUES

- Protocols that are used by networks with options for routing messages between users are designed differently from those previously described. Not only must the integrity of the host information be retained, but messages must be properly formatted for transmission within the network, and then efficiently transferred across each link along the selected network path.

  - Each of these processes requires a different procedure and, in most cases, is under control of different elements within the network. Characteristically, these different levels of protocols are not intermixed to maintain order and consistency throughout the network.

  - The hierarchy of protocol places primary emphasis on the integrity of the host-generated information.

  - From the user's perspective, the communications subsystem can affect efficient transfer of data to a destination as long as the process for transferring the data is transparent to that data.

  - The logical control of the allocation of resources, design, and day-to-day operation of a complex network is achieved by the use of host-to-host, end-to-end, and link protocols.

1. HOST-TO-HOST PROTOCOLS

- Host-to-host protocols are sometimes referred to as transport protocols because of the basic function they perform. The originating host must collect the data, format them into a message, and attach the appropriate header and trailer information for intelligent interpretation by the servicing node (called the "second host").

- The additional information required for the header and trailer varies from network to network.

  - The header consists essentially of those fields that will allow the communications subsystem to deliver the message in an accurate and timely manner.

  - The need for the destination field is obvious, but the requirement for priority and classification fields will vary depending on the characteristics of the data transmitted.

  - Precedence allows a user to identify the urgency for delivering a message, perhaps at the cost of delaying other traffic in the network.

2. END-TO-END PROTOCOLS

- End-to-end protocols refer to those protocols dedicated to transmitting a message from one end of the communications subsystem to the other (that is, between each of the servicing nodes).

  - The message generated by the host is usually in a format that requries the least effort on the part of the host.

- This message must then be formatted for network transmission by the node that serves the originating host.

3. LINK PROTOCOLS

- Link-control procedures between computers are difficult to design because of the complex individual elements that must be accounted for.

  - Link protocols are procedures that allow adjacent nodes to carry on organized communication under normal circumstances. Link protocols, the lowest level in the protocol hierarchy, are far more complex than the other levels.

  - On this level the detailed hardware and interfacing software characteristics of each computer and intervening communications, such as modems and circuits, all have a bearing on how a link will operate.

B. EXAMPLES OF LINK-CONTROL-LEVEL PROTOCOLS

- For years there has been confusion and concern over the nature and application of data transmission procedures. The problem has resided primarily with formats and timings associated with batch transmissions in remote job entry (RJE) applications.

  - Among the most popular protocols are the binary synchronous communications (BSC or BI-SYNC) procedures, which have been implemented on various manufacturers' RJE terminals.

  - In addition to BSC, IBM has also developed the synchronous data link control (SDLC) procedure as a batch transmission protocol for synchronously timed data transmission.

I. BSC-BINARY SYNCHRONOUS COMMUNICATIONS

- BSC is a two-way data transmission system between a compatible host computer and a remote batch transmission terminal.

  - This transmission may be on half-duplex over two or four wires, going over private-lease or dialed-switched lines.

  - All data transmitted with this protocol must be synchronously timed, but the data codes that can be used include EBCDIC, ASCII, or six-bit transcode.

2. SYSTEMS DATA LINK CONTROL

- The primary advantage of SDLC with respect to the more familar BSC procedure is that it exhibits code structure independence.

  - As a bit-oriented protocol, operational requirements for peripheral device control and communications channel functions are performed by bit designation and manipulation.

  - The more traditional protocol, BSC, required specific control characters, which sometimes tended to have multiple interpretations.

3. THROUGHPUT COMPARISON OF SDLC TO BSC

- Data transfer rate is a measure of throughput. Four factors must be considered when measuring data rate: (1) line turnaround time, (2) error rate, (3) record size, and (4) formatting technique.

- Since SDLC and BSC support synchronous line transmissions, line turnaround time should be affected only by synchronization and acknowledgement control character requirements.

- Once a connection between two points is established, individual SYNC characters are not required by SDLC.

- Each transmission of a BSC message must be preceded by three SYNC characters and followed by one SYNC character.

- Up to seven SDLC frames can be transmitted before an acknowledgement must be received, while each BSC block must be acknowledged before the next block is transmitted.

- Both SDLC and BSC use essentially the same 16-bit cyclic redundancy check so the error rate should not be a factor of comparison. Both support variable-length records, so record size should not be a factor.

- The difference in control character requirements make the formatting technique a distinguishing factor affecting data rate, i.e., throughput.

    - SDLC's bit-oriented format requires only one special control character (flag sequence), which appears at the beginning and end of each frame.

    - BSC's character-oriented format reqires ten special control characters, several of which appear in each message block.

- As the size of the unit of transmission (e.g., frame or block) decreases and the number to be transmitted increases, the requirement to acknowledge each BSC block combined with DSC's extra control characters in each block can significanlty increase BSC's overhead.

    - This additional overhead adversely affects BSC's throughout relative to that of SDLC.

C. SNA-DECNET-BDLC-ARPA

- The network architecture, protocol format, line-control procedure, message formats, and the link controls of IBM's SNA, DEC's DECNET, Burrough's BDLC, and ARPANET are examined as an example of various protocols.

I. IBM'S SYSTEMS NETWORK ARCHITECTURE (SNA)

a. Network Architecture

- SNA is a centralized network designed to permit multiple terminals to access and share the files and computing resources of a single centralized host computer.

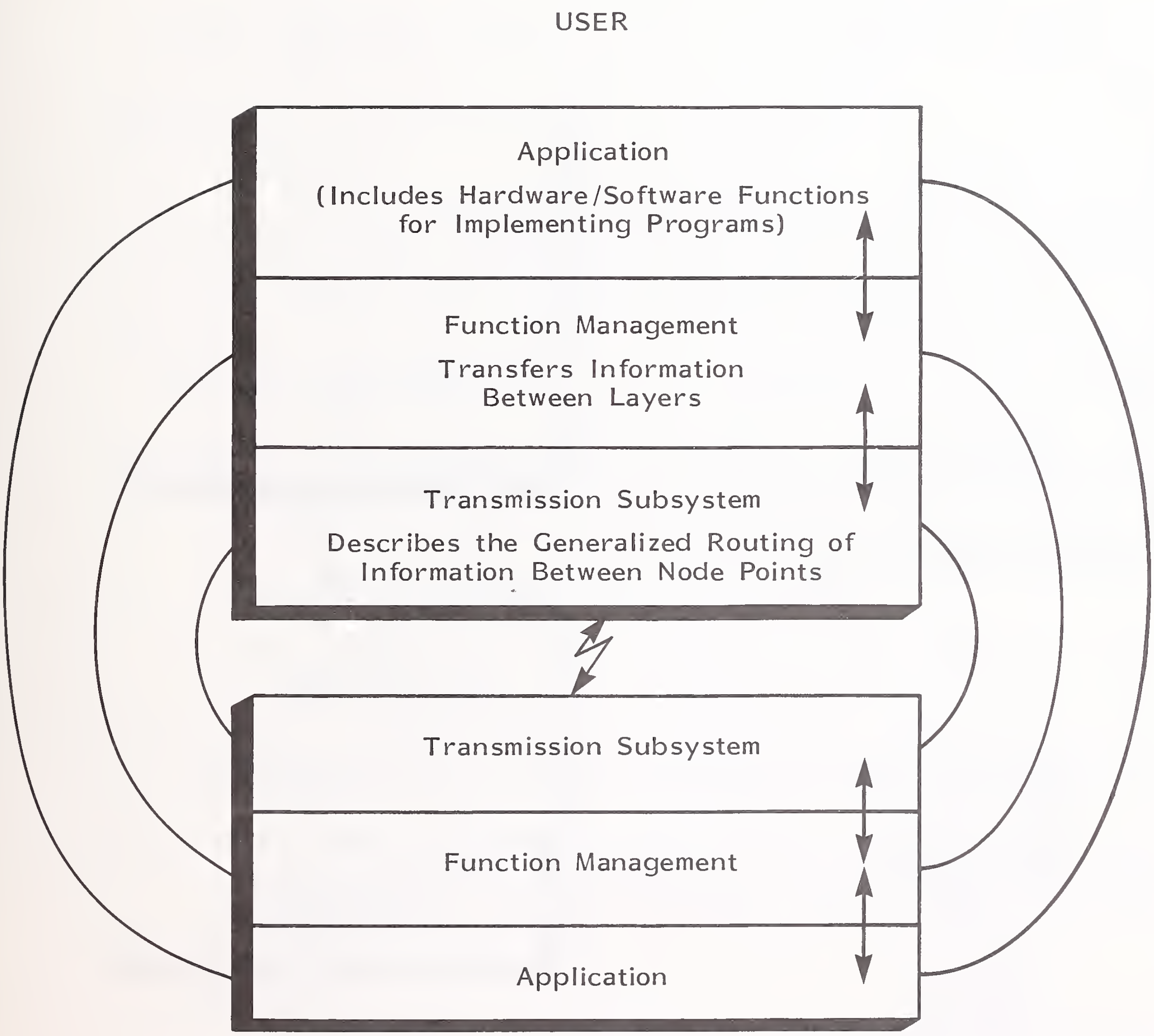
- SNA's layered structure provides for the distribution of teleprocessing functions so that network control activities can be performed in the communications controller as well as in the cluster controllers and terminals.

- Each node in the network is structured into a set of well-defined layers, as shown in Exhibit IV-1. SNA clearly identifies and separates the functional responsibilities of the three major functional layers: transmission management, functional management, and application layers, as shown in Exhibit IV-2.

- Without SNA, all applications, data mapping, and network control (via control units and connecting links) communicate directly with the system controller and then to the operator. Thus, network control cannot take place in either the cluster controllers or in terminals.

EXHIBIT IV-1

THE SNA LAYER CONCEPT

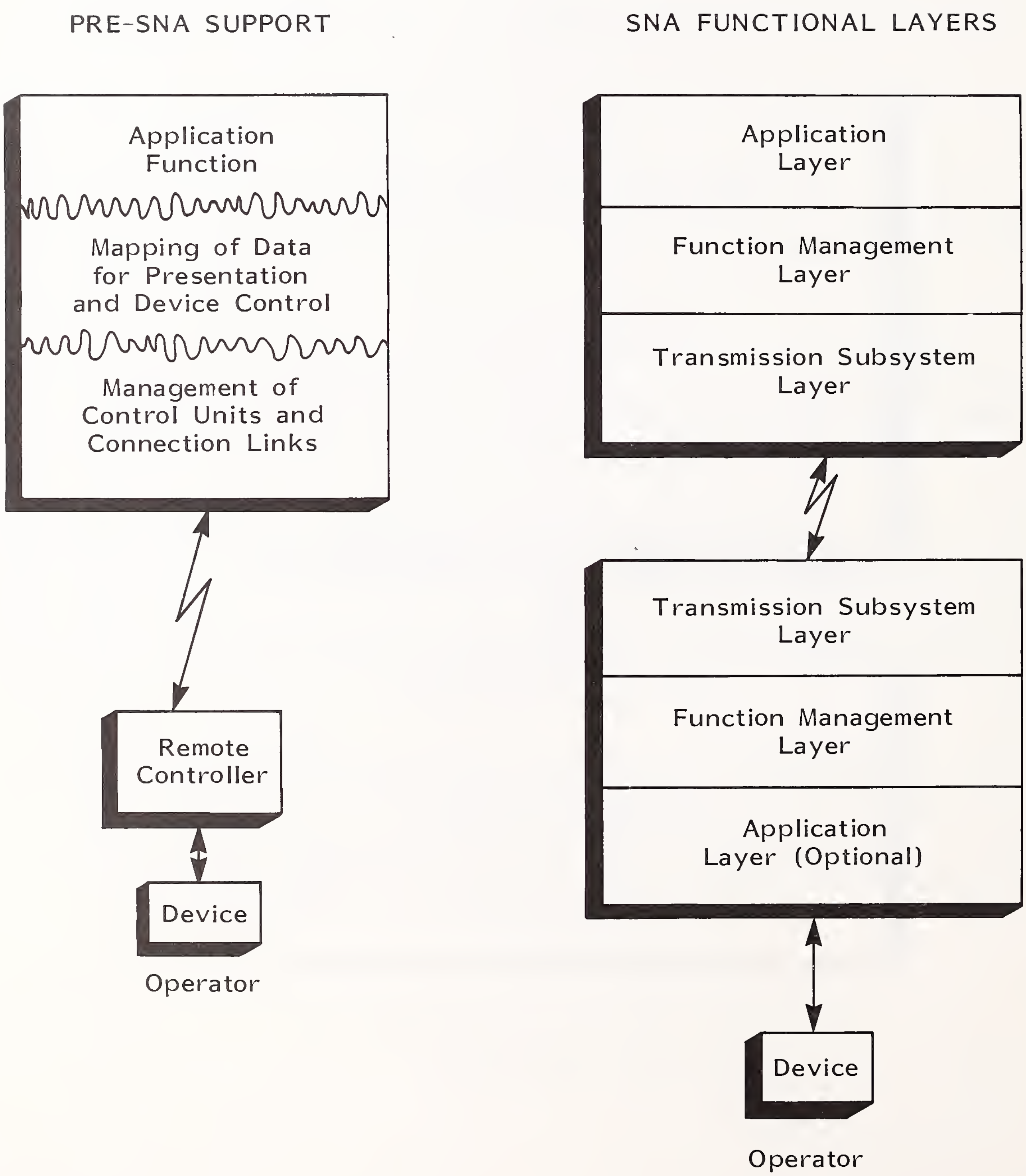


A. Equivalent Layer Communication

B. Adjacent Layer Communication

EXHIBIT IV-2

SNA FUNCTIONAL LAYERING



b. Transmission Management

- The transmission management layer does not examine, use, or change the contents of the data units (text field).

  - The data unit that is passed from the function management layer to the transmission management layer (in the originating SNA node) is then passed intact from the transmission management layer to the function management layer in the destination node.

  - Transmission management may use a variety of physical connections and mission management may use a variety of physical connections and protocols between the nodes of a SNA network.

c. Function Management

- The function management layer controls the presentation format of information sent from and received by the application layer. Function management converts the data into a form convenient for the user and manages the protocol supporting the exchange of user information.

d. Application Layer

- The application layer invokes the services of the function management layer.

  - In the computer, the application layer consists of the application programs from which the terminal user reqests information-processing services.

  - At the terminal, the application layer is represented by the terminal operator.

- In each SNA node, the three layers operate independently. The layered structure of SNA nodes allows end users to exchange information without being involved in procedures like controlling a communication line or routing data units through the network.

  - SNA describes the means by which each layer communicates with a counterpart layer in another node.

  - The individual products define the communication between adjacent layers in the same node.

- SNA components communicate with their counterparts in other nodes by means of headers and trailers inserted in the SDLC frames, as shown in Exhibit IV-3.

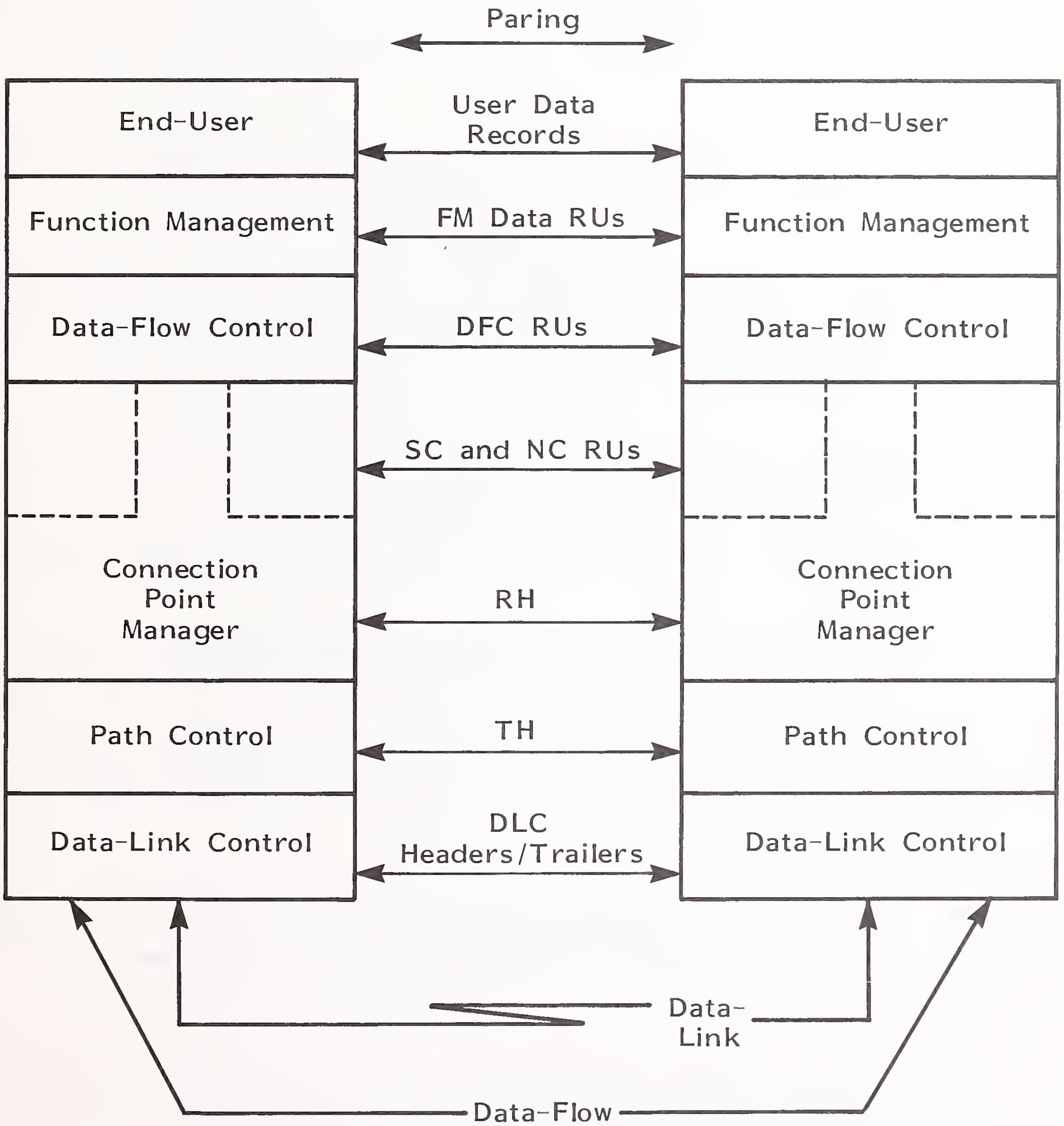
- Data-link control uses the SDLC headers and trailers to transfer a frame between two adjacent nodes.

  - Pat control uses the transmission header and internal line control tables to determine if the data (frame) are intended for this node or are to be routed to another node.

  - Transmission control uses the request-response header to control data flow and to direct the remaining control information and data to the appropriate node components (function management layer). The function management header is used to describe the contents of the request-response unit that contains the end-user information being transferred through the network.

EXHIBIT IV-3

SNA INTERNAL LAYERED COMMUNICATION



TR = Transmission Header

RH = Receive Header (Request/Response Header)

DLC = Data Link Control

SC = Session Control

NC = Network Control

RU = Response Unit

2. DEC'S DECNET

a. Network Architecture

- The digital network architecture (DNA) is a distributed network designed to enable computers linked together in a network to share devices, files, and programs, and to communicate with each other at the program level.

- DNA has a layered structure similar to that of SNA. The software portion of DNA, called DECNET, consists of four distinct functional layers:

  - Data access protocol (DAP)--performs functions for the users, provides DECNET I/0 language, manipulates remote files, and controls remote device operation.

  - Network service protocol (NSP)--(also called logical link protocol) manages the network, routes messages between and within systems, and creates logical links between two connection points in the network.

  - Digital data communications message protocol (DDCMP)--manages the physical link over synchronous, asynchronous, or parallel lines; controls traffic; recognizes errors and retransmits data for error recovery; uses full-duplex channels; and transmits up to 25 messages without waiting for a response.

  - Device drivers and interrupt service routines--interface to the hardware I/0 devices, such as printers, card readers, and other devices.

- The biggest difference between DNA and SNA is that SNA is a centralized network designed around a single host computer, whereas DNA is a distributed network of computers requiring no centralized host.

b. DNA Protocol Format

- DDCMP is DNA's counterpart to SNA's SDLC. DDCMP is message oriented rather than bit oriented like SDLC.

    - DDCMP messages are preceded by a count of the number of bytes in the message. This byte count is used to terminate messages.

    - DDCMP can be used for synchronous or asynchronous communication over serial or parallel lines, whereas SDLC can be used for synchronous communication over serial lines only.

- Like SDLC, DDCMP is designed for full-duplex and half-duplex communication over point-to-point or multipoint facilities. Because DNA separates the user interface and logical links from the data transferred via DDCMP, any message protocol can be substituted for DDCMP as long as programs are developed to implement the protocol in the various computers; i.e., DNA can handle SDLC messages as well as DDCMP.

c. Line-Control Procedures

- DNA's "connection" is equivalent to SNA's "session." NSP is DNA's counterpart to SNA's transmission management layer and performs similar functions.

- Where SNA has a centralized host that manages the entire network, DNA's NSP in each node must maintain sufficient network status information to perform this function. DNA and SNA are at opposite extremes; DNA provides too little network control and SNA's possessive host provides too much.

- DNA provides excellent node-to-node control but almost no network control. This lack of control is tolerable in a small network, but large networks require a network manager to decide what to do when a node or line goes down, to decide where to execute jobs more efficiently, and to decide who has access to what.

- SNA, on the other hand, provides too much control in the host computer. Nodes can do nothing without the consent of the host. When the host goes down, the network is essentially dead.

3. BURROUGHS' BDLC

- BDLC is essentially the same as IBM's SDLC. The network architecture, message formats, and protocol are almost identical. BDLC is compatible with the worldwide standard protocol proposed by the International Standards Organization and can be interfaced with IBM's SDLC. The major difference appears to be in the definition and use of the CONTROL field. SDLC has an 8-bit CONTROL field, whereas BDLC has an 8-bit CONTROL field that is expandable to 16 bits. SDLC is limited to seven unacknowledged messages at any one time, but with the expanded CONTROL field BDLC can handle up to 127 unacknowledged messages.

4. ARPA NETWORK WITH IMPS

a. <u>Network Architecture</u>

- The ARPA Network is a distributed network similar in structure to that of DECNET. The computers and associated software systems that make up the network are heterogeneous. In the ARPANET, each host performs a specialized computing service for the users in the network--hence the motivation for host computers from different manufacturers.

b. <u>Protocol Format</u>

- Each host computer is equipped with a program called the network control program (NCP).

- The NCP arranges for connections to be established and terminated between programs on one host, and programs on another host, and performs other monitoring functions for user programs.

c. Line-Control Procedure

- The communication controllers at each node of the network are called interface message processors (IMPs). The IMPs ensure that the packets are reassembled into the original message for transmission to the destination host, performing error-checking and code conversions as required. The IMPs control the routing of packets from node to node.

- The ARPANET is a packet-switching network.

d. Message Formats

- ARPANET uses a variable-length, bit-oriented message format.

  - Packets are 1008 bits maximum and messages are 8063 bits maximum length; thus there are a maximum of eight packets per message.

e. Link Control

- The ARPANET uses an adaptive routing discipline.

  - Paths between nodes are selected dynamically, based on traffic volume and line conditions at the moment. Thus, both inoperative and congested links are bypassed.

  - The NCP in each host establishes logical links through the network.

  - The IMPs control the transmission of messages over links from node to node.

V CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

- Vendors will either continue developing their own proprietary methods for interconnecting or will agree to conform to the OSI model. As OSI becomes accepted, users will begin to expect demands that vendors conform to the OSI mode.

- The major threat to OSI is from computer manufacturers' own methods for interconnections, such as IBM's SNA or Digital's DECNET.

- An X.25 capability will probably be offered by most manufacturers by late-1985, based upon the extensive network development undertaken over the last several years.

- SNA, with currently about 70% of the market and an IBM commitment to expand SNA capabilities, will continue to dominate the architectural market for many years to come.

B. RECOMMENDATIONS

- With the growing emphasis on network control and diagnostic capabilities, it is logical to consider using the new interfaces as soon as they are generally available. Rather than having a proliferation of smart modems that only work with the manufacturer's network control system, a standardized set of control functions, such as loopback testing, will allow for more flexibility in network development.

- The role of SDLC will continue to expand with increased acceptance by the user community. Be aware, however, that IBM is now committing itself to a HDLC hierarchy compatibility. When a product will be released is not predictable at this time.

- As DEC continues to grab larger shares of the market due to its unique ability to service the process control industry (chemicals, space science, automated processes, etc.), the influence of its DECNET network architecture will increase. It will pay to carefully evaluate DECNET's utilization in those relevant industries where DEC has a market niche.

- The network interface arena is still highly volatile, and many companies have new products under test and development. The critical factors will be CCITT and other standards, and the acceptance in the user community of non-compatible (or non-IBM) network interfaces.

- IS managers who in their planning fail to consider this volatility could be neglecting responsibilities; the best approach is to carefully monitor this marketplace and leave sufficient slack in the planning process to accommodate significant changes over the next several years.

APPENDIX

SNA: Challenges & Opportunities

Survey Questionnaire

1. Name of Company ______________________________

2. Do you have or will you have extensive in-house private networks?

   ____

3. Do you use or require packet switching? ______________

4. Which transmission protocols do you use (or are planning to use)?

   SNA ______

   X.21 ______

   X.25 ______

   DECNET ______

   Other ______

5. Do you know which protocol layers you are currently working with:

   Data Link Control _____?

   Path Control _____?

   Transmission Control _____?

   Data Flow Control _____?

   Presentation (Code and Format) Services _____?

6. What will be your future network requirements? ______________

   ____

   ____

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